Polypropylene "*in vivo*" Implantation in Inguinal Hernia Repair – Adverse Reactions

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Polypropylene mesh is the preferred biomaterial used in iguinal hernia repair due to its flexibility, strength, rapid integration by surrounding tissues and resistance to infection. Despite being rare, adverse reaction to polypropylene mesh "in vivo" implantation are still a reality in clinical practice. Infections of an implanted mesh are extremely rare, with an incidence lower than 0,1% in laparoscopic inguinal hernia repair, respectively 1,5% in the open approach. However, when this complication occurs, managing it can be extremely difficult. This paper presents the case study of a 41-year-old male patient operated for right inguinal hernia, using a polypropylene mesh implanted laparososcopically. As a delayed postoperative complication, he developed mesh infection, which could not be treated with conservative measures. Definitive treatment consisted in surgical excision of the mesh and one titanium clip, using a hybrid technique, which combined the laparoscopic approach and open surgery. The postoperative course was favourable, with resolution of the symptoms. No recurrent abscess or hernia were noted during 18 months follow-up. In conclusion, removal of the mesh using the hybrid approach, can be a solution for polypropylene mesh infection.

Keywords: polypropylene mesh infection, hernia repair, mesh excision, hybrid approach.

Inguinal hernia is one of the most common pathologies in general surgery. It is caused by a weakening of the abdominal wall, which allows intraabdominal organs to protrude through the defect, causing a visible bulge in the inguinal region [1]. Its incidence is higher in male patients and it increases with age. The lifetime risk of developing an inguinal hernia is 27% for men, respectively 3% for women. For male patients aged 25-39 the incidence of inguinal hernias is 7.3% and it increases to 22.8% in patients older than 60 [2].

Inguinal hernia repair is one of the most frequent surgeries performed in general surgery worldwide [1]. Hernia repair consists in strengthening the weakened abdominal wall using a mesh. Ever since synthetic meshes have been introduced in abdominal hernia repair by Usher in 1959 [3], recurrence rate has dropped significantly [4]. Therefore, the implantation of polymeric biomaterials is now the gold standard in hernia repair [5,6]. The mesh can be implanted using either open surgery or the laparoscopic approach. In the laparoscopic technique, the mesh is implanted in the properitoneal space, either through the abdominal cavity (TransAbdominal ProPeritoneal repair – TAPP) or without entering this anatomical space (Total ExtraPeritoneal repair - TEP).

The surgical implantation of the mesh in the inguinal region provides biomecanical strength to the weakened abdominal wall [4]. The ideal mesh should possess adequate mechanical characteristics, be easily handled, readily integrated into the surrounding tissues, biologically inert and resist rejection and infection [1].

The most important mechanical characteristics of a surgical mesh are tensile strength and elasticity. The implanted biomaterial should be able to withstand the forces acting on the abdominal wall and also possess sufficient mechanical strength to repair the weakened abdominal structures [1]. In order to withstand the maximum intraabdominal pressure, generated during coughing or jumping, the surgical mesh should withstand pressures of at least 180 mmHg or have a tensile strength of 16 N/cm^2 [4]. At the same time, the prosthesis should mimic the natural distensibility of the abdominal wall. In order to achieve this, the mean elasticity of the mesh should be between 11 and 32% at a force of 16N, in all directions (horizontal, vertical and oblique) [1].

The reinforcement of the weakened abdominal wall is achieved by allowing integration of the mesh in the surrounding tissues. Integration of the biomaterial is achieved by ingrowth of fibroblasts, macrophages, blood vessels and collagen around the mesh fibers, creating a strong and secure repair [1,4].

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The mesh should be biologically inert. Biomaterials should exist in contact with human tissues without causing them harm. Ideally, the mesh should not interact with undesired tissues, such as the bowel [1].

Despite extensive research, no single ideal mesh has yet been produced. The large variety of meshes available on the market proves that in order to achieve the best clinical outcome, the choice of the synthetic material should be adapted based on the particularities of each case [5]. Biomaterials used today in hernia repair can be absorbable, non-absorbable, composite, coated or impregnated. Meshes are further categorised according to filament structure, pore size and weight [1].

Polymer fibers can be braided (multifilament) or not (monofilament). Multifilament meshes are associated with an increased risk of granuloma formation and, most importantly, infection [1].

The porosity of a prosthesis refers to the ratio of open to solid space with respect to volume, area or weight. Meshes with pores larger than 75 μm are called macroporous, while those with smaller pores are microporous. Macroporous meshes are quickly integrated and more resistant to infection. As well as that, they are more flexible and decrease granuloma and seroma formation. Their main disadvantage is the increased risk of intraabdominal adhesions [1].

The weight of the mesh depends on several physical properties of the biomaterial, such as fibre thickness, tensile strength and elasticity. Heavyweight meshes have thick fibres, small pores and high tensile strength [1]. They typically weigh 100g/cm^2 (1.5 g for 10x15 cm mesh) [7]. Heavyweight meshes are associated with intense foreign body response, fibrosis, a loss of abdominal wall compliance and contraction (shrinkage) after "in vivo" implantation. Therefore, the risks of chronic inguinal pain and hernia recurrence are significantely higher. Newer lightweight meshes have thinner filaments, improved elasticity, larger pores and contract less after "in vivo" implantation [1]. They usually weigh 33 g/ cm^2 (0.5 g for 10x15 cm mesh) [7].

Prosthetic materials available on the market today are relatively inert and biocompatible. However, "in vivo" implantation can be associated with complications, caused by local inflammation or infection [5,8].

Non-infectious complications are caused by local inflamatory reactions in response to mesh implantation. They consist of foreing body reactions, rejection and migration of the mesh. Synthetic materials like polypropylene can produce varying foreign body reactions, such as granuloma, seroma, fibrosis, calcification, thrombosis and mesh adherence to the bowel. Adhesions can lead to chronic abdominal pain, intestinal obstruction, bowel perforation and enterocutaneous fistulae [1].

Mesh infection is a rare complication of inguinal hernia repair, with an incidence of 1.5% following open surgery. In the laparoscopic approach, the rate of mesh infection has been reported between 0.03% and 0,.095% [9]. In most cases, the causative agent is *Staphylococcus spp*, especially *Staphylococcus aureus*, which is commonly present on the skin. This microorganism has been associated with biofilm formation on the surface of the mesh. Once the mesh is contaminated, bacteria adhere to the surface of the biomaterial, followed by proliferation and secretion of an exopolysaccharide matrix that serves as the biofilm skeleton. Biofilm proctects bacteria from antibiotics and the host's immune system [10]. At the same time, biofilm interferes with the diagnostic techniques commonly used for bacterial detection, making mesh infection difficult to diagnose [11].

The risk of developing this complication is influenced by patient factors, surgical technique, the type of implanted mesh and by the methods used for disinfection and sterilisation. Large, complicated and recurrent inguinal hernias are significant patient-related risk factors. Furthermore, a personal history of surgical site infections increases the risk for mesh infection [6]. Other risk factors include comorbidities such as chronic pulmonary disease, obesity, diabetes, imunosupression, smoking and skin infections[6]. Risk factors related to the surgical procedure consist of a long operating duration, an extended area of dissection, increased mesh dimensions [6] and performing another surgical procedure in the same operating time (such as an enterectomy) [10]. Inadequate surgical technique, such as intraoperative contamination of the mesh or the surgical site, tissue damage, poor hemosthasis or poor wound closure, also increases the risk of mesh infection [6]. Postoperative seroma and the evacuation of the fluid are associated with higher infection rates [9]. Risk factors associated with the biomaterial are multifilament and microporous surgical meshes. They are easily colonised by bacteria, but at the same time, they impede macrophage migration, thus promoting bacterial growth [8]. Sterilisation and disinfection methods influence the incidence of mesh infection. Bacterial contamination of antiseptic solutions used in preoperative skin preparation, suboptimal sterilisation of surgical instruments (especially concerning the laparoscope) and resterilisation of the mesh and fixation devices increase the risk of this complication [4,10].

Nowadays, three polymeric biomaterials are most commonly used to produce surgical meshes: polypropylene, polyesther and expanded polytetrafluorethylene (ePTFE) [4]. Polypropylene is the preffered biomaterial in iguinal hernia repair due to its strength, flexibility, rapid integration by surrounding tissues and resistance to infection [7].

Experimental part

Material and methods

The study was conducted in a period of aproximately 18 months, between october 2017 and march 2019, in the Euroclinic Hospital, Regina Maria in Bucharest. The paper presents the case of a 41-year old, male patient who presented for a parietal fistula tract located in the hypogastric region, with a small discharge of pus (fig. 1). The suppuration had been persistent, with an evolution of aproximately 2 years following laparoscopic hernia repair.

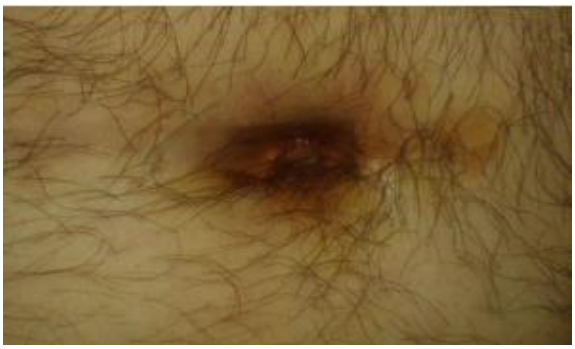

Fig 1. Photographic image showing the external orifice of a parietal fistula tract, located in the hypogastric region

The patient had no comorbidities. His medical history included a right inguinal hernia for which the patient underwent a laparoscopic TAPP repair in september 2015, in a different hospital. The medical documents that the patient received at the time recorded the implantation of a polypropylene mesh in the right inguinal region, but the porosity and the weight of the mesh could not be established. Three months after the repair, in december 2015, the patient was admitted for pain, induration involving the skin and subcutaneous tissues with a diameter of 20/20 mm and inflamatory changes of the skin, located in the hypogastric region. Computer tomography was performed, which showed a collection in the right inguinal region with a diameter of 54.2/38.1 mm, communicating with a second collection of 883/43.2 mm located in the hypogastric region. Surgery was performed in an open approach. A horizontal incision was performed in the hypogastric region, 200 ml of pus were evacuated, followed by lavage and drainage of the remaining cavity. Intraoperatively, the mesh previously implanted was checked. It appeared correctly integrated and did not show signs of bacterial contamination. As a result, the mesh remained "in vivo". Postoperatively, the drainage was removed and the patient was discharged 2 day after the surgery.

In october 2017, approximately 2 years following laparoscopic TAPP hernia repair, the patient presented at the Euroclinic Hospital for persistent parietal suppuration. He presented with a chronic fistula tract with an external opening with a diameter of approximately 10 mm, located in the hypogastric region. Is was accompanied by local induration and erythema and a small discharge of pus. A sample of pus was collected and bacterial examination was performed. The results came back negative and no bacterial growth could be detected.

Magnetic resonance imaging was performed using the Philips Achieva dSTREAM, 1.5 Tesla equipment. The lower abdomen and pelvis were examined, showing a collection with thick walls in the right inguinal region, posteriorly to the musculoaponeurotic layer of the abdominal wall, in close contact with the right transversus abdominis muscle. The examination also revealed a fistula tract with a length of approximately 10 cm and a width of 1 cm. The fistula tract presented an internal opening in the collection located in the right inguinal region and an external opening in the hypogastric region, at the midline, 2 cm cranial to the pubic symphysis (fig. 2A and fig. 2B).

Differential diagnoses included foreing body reactions to the implanted synthetic material and mesh infection. In order to establish positive diagnosis the following factors were taken into account: patient history, clinical examination and magnetic resonance imaging. Mycrobiological examination, which failed to isolate any bacteria, was considered to be false negative. Therefore, the positive diagnosis was chronic deep surgical site infection following laparoscopic TAPP right inguinal hernia repair, with mesh infection.

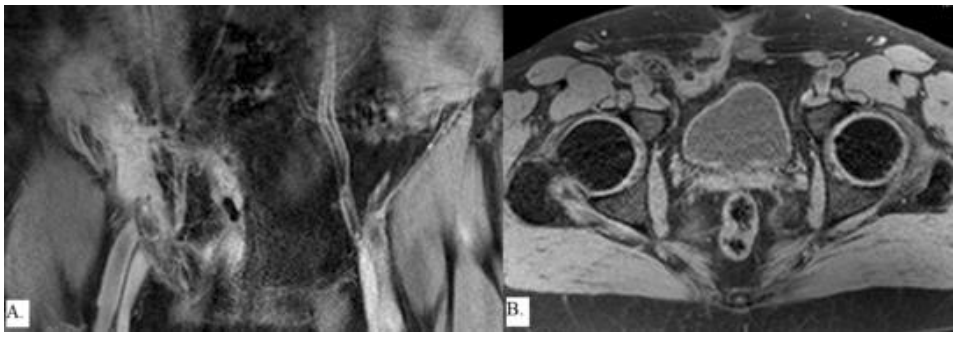

Fig 2. MRI aspect of parietal suppuration following TAPP hernia repair. 2A. Collection in the right inguinal region.2B. Fistula tract from the collection to the skin in the hypogastric region

The patient received a mixt treatment, which combined medical and surgical treatment. Medical treatment consisted of broad-spectrum antibiotic treatment which was administered intravenously over the course of hospitalization and orally after the patient was discharged. Surgical treatment consisted of complete explantation of the mesh and drainage.

The surgery was performed under general anesthesia with orotracheal intubation. A hybrid technique was chosen, combining the laparoscopic TEP aproach with open surgery. A 10 mm incision was performed in the umbilical region, which allowed the division of the anterior rectus sheeth on the right side. A 10 mm trocar and the laparoscope were inserted and the properitoneal space was insufflated to a maximum pressure of 12 mmHg. Using the laparoscope, blunt dissection of the properitoneal space was performed. In figure 3, the intraopertive aspect of the properitoneal space dissection obtained using the Olympus full HD, high resolution 3CCD laparoscope (CH-S190-XZ-E/Q) is shown. A second 5 mm trocar was inserted at the level of the midline, 6 cm below the umbilicus, in order to complete the dissection.

Adhesions were discovered in the properitoneal space, blocking the visualisation of the polypropylene mesh previously used for hernia repair. As soon as they were divided, the infected mesh was identified (fig. 4).

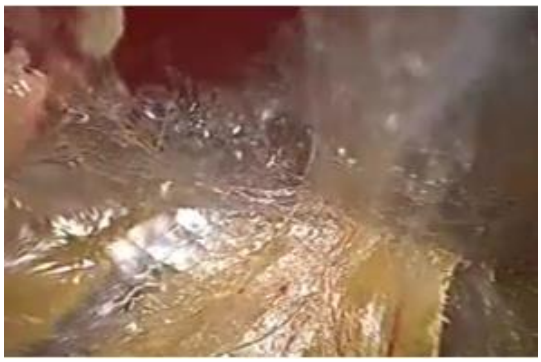

Fig 3. Intraoperative aspect of blunt dissection of the properitoneal space

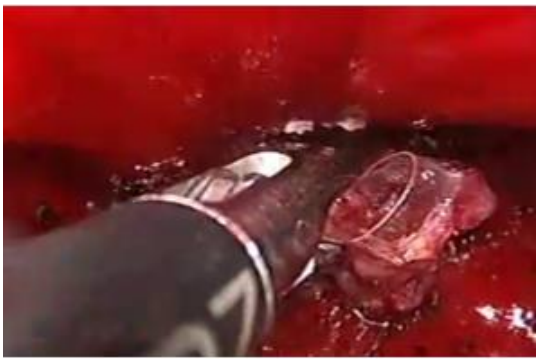

Fig 4. Intraoperative aspect of the “in vivo” polypropylene mesh

In order to complete the dissection of the mesh and to facilitate extraction, open surgery was associated to the laparoscopic approach (fig. 5). A 6 cm incision was performed in the hypogastric region, 6 cm above the pubic symphysis. Using the hybrid technique, all foreign materials were explanted. They included the polypropylene mesh and a titanium clip that was discovered intraoperatively (fig. 6). The fistula tract in the hypogastric region was excised. A drainage tube was positioned in the remaining cavity (fig. 7).

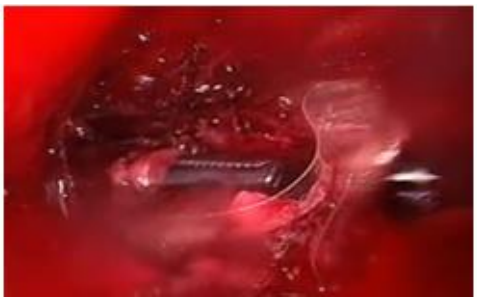

Fig 5. Intraoperative image showing the extraction of the polypropylene mesh using a

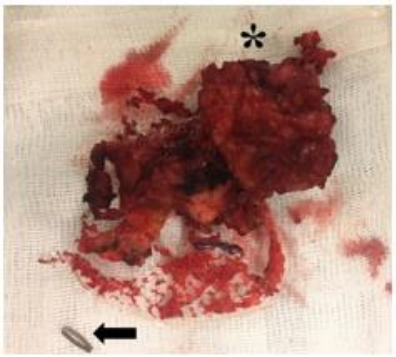

Fig 6. Photographic image of explanted foreign materials. Asterisk – polypropylene mesh. Arrow – titanium clip.

Fig 7. Photographic image of immediate postoperative aspect. Red arrows – incisions for the laparoscopic TEP approach. Blue arrow – 6 cm incision in the hypogastric region for the open approach. Asterisk – drainage tube.

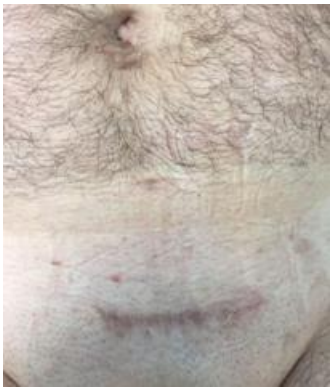

Fig 8. Photographic image of postoperative aspect at 18 months follow-up

Results and discussions

Postoperative course was favourable, with complete resolution of symptoms, an excelent esthetic result and no complications (fig. 8). The patient was hospitalised for 48 hours postoperatively. In this period, broad-spectrum antibiotic treatment was administered intravenously. The drainage was monitored and it was removed 48 hours

postoperatively, when its output decreased to less than 10 ml of fluid in 24 hours. After the patient was discharged, oral antibiotics were administered 5 additional days. Seven days after discharge, the skin sutures were removed and the patient resumed normal activities and returned to work.

The total follow-up period was 18 months, with appointments sheduled at 1, 6, 12 and 18 months postoperatively. The evaluation included clinical examination and soft tissue ultrasound. During follow-up, no signs of recurrent hernia or infection were noted.

Deep surgical site infections following inguinal hernia repair with mesh contamination are challenging when it comes to diagnosis and treatment. Diagnosis relies in many cases only on clinical examination and imaging techniques, considering that oftentimes microbiological examination fails to isolate and identify the causative agent. False negative bacteriological cultures can be a consequence of prior antibiotic treatment, infections with fastidious bacteria [12] or biofilm formation on the surface of surgical mesh. Therefore, in order to establish positive diagnosis, further investigations are required, such as histopathologic examination of the infected mesh or molecular tests [11].

An infection of the mesh generally requires a combined, medical and surgical treatment. Medical treatment includes intravenous antibiotics that cover *Staphylococcus spp*, especially *S. aureus* [8]. Surgical treatment consists of complete explantation of the mesh, along with any other foreing materials, such as sutures, tackers [10] or clips.

The surgical excision of the infected mesh can be performed using open or laparoscopic approach (TAPP or TEP). The open approach requires large incisions. On the other hand, the laparoscopic technique is minimally invasive and is associated with reduced postoperative pain, shorter hospital stay and an early return to normal activities [13]. Chowbey et al. reported 10 cases of laparoscopic explantation of infected meshes using the transabdominal approach (TAPP), with favourable outcomes [14]. However, using this technique to remove an infected mesh can lead to contamination of the peritoneal cavity and intraabdominal adhesions. In order to avoid these complications, the total extraperitoneal approach (TEP) can be used instead. Chihara et al. reported the case of a patient with chronic mesh infection who underwent laparoscopic TEP mesh excision, with good results [13].

Cases of conservative treatment have been reported in the literature. They associate systemic and local antibiotics, percutaneous drainage of the collections (ultrasound or CT- guided), partial mesh excision [15] or negative pressure wound therapy [10], in various combinations. This approach aims to preserve the implanted mesh, thus avoiding inguinal hernia recurrence. The disadvantages of this treatment option are the long hospital stay, adverse reactions caused by long term antibiotics [15] and the significant rate of infection recurrence [16, 17].

Alston et al. reported in 2013 one case of mesh infection with *S. aureus* following inguinal hernia repair, that was treated conservatively. The therapeutic management included evacuation of the collection, pigtail drainage, local flushes with gemtamicin and saline and long term oral flucloxacillin. The reported follow-up was 7 months and during this time, no signs of recurrent infection were noted. Conservative treatment was considered successful [15]. In 2014, the same authors reported that after oral antibiotics were stopped, the infection recurred. The patient eventually received surgical treatment and the mesh was explanted laparoscopically, with favourable postoperative evolution [16].

Avtan et al. reported three cases of mesh infections following TAPP inguinal hernia repair that were initially treated conservatively with antibiotic coverage, drainage and lavage. However, the infections could not be eradicated using conservative methods and eventually the patients received surgical treatment. The meshes were completely removed, without complications [17].

Conclusions

The management of polypropylene mesh infections following inguinal hernia repair can be a challenge. Conservative treatment options include antibiotic coverage, percutaneous drainage, partial mesh excision or negative pressure wound therapy, in various combinations. This approach preserves the implanted mesh and prevents hernia recurrence, but is associated with long hospital stay, adverse reactions to long term antibiotics and a significant risk of infection recurrence. Considering these disadvantages and based on the research conducted in this paper, the recomended approach for mesh infections combines medical treatment (antibiotic coverage, including *Staphylococcus spp*.) and surgery. The surgical treatment consists of complete explantation of the infected mesh along with other foreign materials such as sutures, tackers or clips. The hybrid approach that combines laparoscopic and open surgery can be a solution in these cases, allowing the excision of foreign materials and chronic fistula tracts, thus eradicating the infection, with good functional and esthetic results.

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Manuscript received: 7.05.2019